

Preparing for the Next Generation of Planetary Surface Exploration

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Moderator: Jeffrey Nee

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Coordinator: Welcome, thank you for standing by. For the duration of today's conference all parties will have an open line. We ask that during the conference if you're not speaking to either utilize your mute feature on your phone or press Star 6 to mute or unmute your line. I'd like to inform all parties that today's conference is being recorded. If you have any objections, you may disconnect at this time. I would now like to turn the conference over to Jeffrey Nee. Thank you. You may begin.

All right, hello everyone and welcome. I'm Jeff Nee from the Museum Alliance, the moderator for today's talk. Thank you to all of you for joining us and to anyone listening to the recording in the future. Today we'll be talking all about preparing for the next generation of planetary surface exploration. As a final reminder as (Kurt) said, please mute your phone if you're not going to be talking and do not put us on hold even if you have to step away because some phones play holding-music which can disrupt the talk. Just be sure your phone is on mute and we'll be all set to go.

The slides for today's presentation can always be found on the Museum Alliance and Solar System Ambassador sites. If you have any problems, you can email me at jnee@jpl.nasa.gov. Our main speaker today is Dr. Kelsey Young. Kelsey graduated with a PhD in Geological Sciences from Arizona State University. She is part of the Survey RIS⁴E Team where she supports the

team's goal of incorporating portable geochemical technologies into terrestrial fieldwork in order to prepare for future planetary surface missions.

Also on the line is Laura Bleacher, the Solar System's Exploration Division's Education and Public Outreach Lead at NASA Goddard Space Flight Center. You can read more about our speakers as always on our Web sites but for now I want to get to Kelsey's talk, so Kelsey take it away.

Dr. Kelsey Young: All right thank you. Thanks for joining us here today. And as this is being recorded if anybody has questions later that are on the line today my email address is on the last slide of the presentation so please feel free to email me any questions later. So I'm going to be talking about operational field tests in analog environments as well as to in portable instruments and the role of incorporating them into the next generation of planetary surface exploration.

And I apologize I didn't put slide numbers on the slides but I'll indicate when I'm switching to the next slide which I'll do right now. So the next slide [Slide 2] indicates, I just wanted to introduce myself and what I'm going to be talking about. My name is Kelsey Young. I work at the NASA Johnson Space Center and I study planetary field geology so figuring out what we need to do to conduct planetary field geology on other planetary surfaces.

I have my Bachelor, Masters and PhD all in Geology, a Bachelors from Notre Dame and Masters and PhD from Arizona State University. My PhD was again in using analog sites or sites that looked like other planets to study processes, scientific processes and developing technology for the next generation of planetary surface exploration. So I'm going to move to [Slide 3] which shows all of the known planets in our solar system. We've sent missions to each one of these planetary bodies whether they be orbiters, landers or rovers to investigate the processes that shape these planets.

If you move to the next slide, [Slide 4] you'll see pictures of each mission orbiter, landers, rovers that have gone to all of these planetary bodies. You can see that it's slightly out of date as each of those; Rosetta Mission ended about a month ago. But this just show - goes to show all of the efforts that NASA and its international partners have in exploring surface processes on other planets.

If you move to [Slide 5] you'll see a brief Apollo history of planetary surface exploration. Apollo represents the only time that human beings have ever set foot on another planetary body and it's to be the sixth time with 12 people from '69 to '72. These Apollo astronauts were collecting samples, deploying surface science experiments and for the final three missions they also have the lunar roving vehicle which you can see pictured in the corner of the picture here next to large outcrop there on Apollo 17. If you move to the next slide [Slide 6], you'll see scientific drivers for planetary exploration. So although the Apollo surface missions made large strides towards understanding the lunar geologic history, a large number of advancements have been made since then and there is still a large number of outstanding science questions across all of the targets of interest specifically for human exploration which I'll spend the remainder of this talk talking about.

Across the top of this slide are all potential free target bodies that human beings might visit. I go back to the moon as pictured here and a concept sketch from the Lunar Reconnaissance Orbiter. We also we'll hopefully have boots on the ground on Mars. Shown here in the picture is the Mars Science Lab curiosity rover currently driving around on the surface of Mars. And then we also might send humans to small bodies. The Osiris Rex Mission just launched recently to go and sample an asteroid and return to Earth. So the areas of scientific inquiry for all of these bodies include geology, geophysics

geochemistry, atmospheric science, chemistry as related to life and all of - the investigations of all of these different areas of interest can include varying levels of human interaction.

We already have orbiters, landers and rovers around and on other planetary surfaces. So we hope to send humans there so what scientific questions can be answered with humans in the loop and how do we accomplish this? And that's what I'm going to be talking about today.

So if you move to the next slide [Slide 7], this sort of sums up what I just said. These are the three potential target destinations for crew missions. And that include small bodies going back to the moon and eventually going to Mars. Each one of these destinations introduces complexities from varying communications delays which gets pretty far - pretty long when you're going to the Martian surface as well as varying atmospheric and gravity conditions which impact the way we're going to conduct field science on these planetary bodies. So as we think about developing technology which I want to talk about today we want to develop flexible technology that's going to apply in a variety of these scenarios and atmospheric and gravity conditions.

So if you move to the next slide [Slide 8], it shows the graphic of NASA's journey to Mars. Of course we start here in low Earth orbit with the International Space Station. We're going to move out potentially with the Orion crew capsule as well as potentially the Asteroid Redirect Mission that's in the design phase is now. And then this all leads toward the journey of Mars where we hope to one day put astronauts on the surface of Mars. So if you move to the next slide [Slide 9], this shows this plan a different way which I think is important as we think about the technology development stage of preparing for this journey to Mars. We have the Earth reliance phase which is

currently underway with the International Space Station and will continue and US private companies continue to provide access to low Earth orbit.

We have the proving ground phase where we test and demonstrate technology we need to go to Mars. And then of course we have the Earth independent stage, the Mars ready stage where we're actually going to send people a long way away from our planet out to Mars. So if you move to the next slide [Slide 10], we're moving forward from Apollo surface exploration in terms of having humans in space. We have the International Space Station in orbit around Earth right now the size of a football field. You can see it in this picture.

We're observing earth now from ISS. We're conducting science experiments like you can see in the images. We're preparing for commercial crew. You can see the picture in the top right of Kate Rubins and Jeff Williams looking at one of the crew capsules approaching the ISS. And we're also looking at things like human factors and human health for long duration spaceflight using the ISS.

So NASA's studying things like crew health, how is their bone density, their eye health going to be affected by living in this environment for the long period of time necessary to get to and from Mars? So if you move to the next slide on [Slide 11] we're going to start thinking about moving forward with planetary surface exploration. And what I'm going to talk about today is what we need to do to get ready to send human beings to the destinations I just mentioned. And what you'll still hear me saying over and over again is we have to test redesign and test again over and over and over again. We need to iterate on these technologies so that we're ready when human beings eventually visit another planetary destination.

And this requires an integrated approach. It's not just scientists. It's not just engineers. It's everyone working together in an integrated approach to develop the science concept, the operational modes that we're going to operate in as well as the technology we need once we get to the other planets. And that will get us there. So if you move to the next slide [Slide 12], this sort of shows what I'm going to be talking about today. I'll talk about integrated operational field tests or analog tests. I'll talk about instrument development, so once we actually put human beings boots on the ground, what are they going to hold in their hands to really do exciting and new science, as well as how we need to train the crew to prepare for an eventual exploration mission.

So if you move to the next slide, [Slide 13] it shows that terrestrial field testing has been a crucial part of planetary surface exploration ever since Apollo. The picture on the left shows the Apollo 17 crew Jack Schmidt and Dean Cernan preparing in the desert of Arizona for their mission on Apollo 17 as well as two of NASA's habitat rovers that were tested in this picture in 2010 to prepare for eventually having astronauts on Mars or the moon.

Move into the next slide [Slide 14], it shows all of the analog projects that's NASA been involved with most currently and in the last couple of years. I'm definitely not going to talk about all of them because there's certainly a lot to talk about but I'm going to go over a couple of the analog missions that I personally worked on and explain how we're preparing for this new generation of surface exploration. And when I say analog test or operational field test I mean a multidisciplinary field test that allows for early and to end testing of both operational concepts so how we're going to operate once we get to a destination as well as the hardware needed and to test these things together in a real operational environment. And we really make an effort to evaluate these objectives that map to specific technology gaps or knowledge gaps both in science, operations and technology.

If you move to the next slide, [Slide 15] I want to introduce the desert RATS field test. And RATS is Research and Technology Study. The desert RATS field test comprised an integrated team of like I said, engineers and scientists that span multiple agencies, education centers, academic institutions even the military as well as commercial and international partners. And we're trying to test and validate hardware and software as well as mission operation concepts to identify where we are now and where we need to be when we finally visit another planetary surface.

And this picture is like we like to call it the 2010 the 2010 Desert RATS family photo. You can see all the technology assets that we're testing that year. You have habitat rovers as well as a habitat laboratory for astronauts to conduct (in situ) scientific analyses events.

So moving to the next slide [Slide 16], I go over the technology that we tested in the Desert RATS mission. We have course had the habitat rovers. The idea here is that multiple people could live in one of these habitat rovers for a couple of weeks at a time. The Desert RATS 2010 mission had two crewmembers per rover, one astronaut and one field geologist to test these technologies and operational concepts. We also had sample collection technology so evaluating moving forward from the technologies we had in Apollo to what we might need for future exploration. And we also had habitat laboratory. You can actually see the rovers can dock to the edge of the habitat lab and allow the astronauts to move in, live in and work inside of this habitat lab to explore the samples that they collected on that mission.

Moving to the next slide [Slide 17], you see the operations concept tested in Desert RATS. The biggest one is that we have integrated EVA science operation, EVA meaning extravehicular activity. So every time an astronaut

goes boots on the ground and does a (space-walk) they're conducting it EVA. And what Desert RATS is doing was examining the operational concept, the (CON OPS) that enabled this complex interaction between Mission Control Center back in Houston as well as the astronaut crew who's living in the rover. In Desert RATS specifically tested the communication structure over varying communication delays so whereas the communication delays between here and the moon are negligible as you move to the Martian surface you're going to have quite a communications lag between mission control and the crew. Understanding how science information is passed back and forth in real-time over this delay is really important and is something we investigated in Desert RATS.

We also had a sample collection and Curation procedures. Once an astronaut led EVA how did they collect samples and store them for return to Earth? And we also studied crew training which I'm going to talk about at the end of the talk. Moving to the next slide [Slide 18], we actually see the we were doing real science. We were testing in the San Francisco volcanic field north of Flagstaff, Arizona. It's a good analog site for a lot of the sites we see in the moon and Mars. We were in real-time collecting samples and mapping the area to understand the volcanic history of the region. And since then we've also conducted follow-up science.

Just about three weeks ago I was out following the traverses we took in 2010 with geophysical instrumentation to use (digmometers), ground (hand training) and magnetometers to understand the sub sources structure of the area we traversed over in Desert RATS.

Moving onto the next slide [Slide 19], I introduced the NEEMO analog project. So moving on from Desert RATS. NEEMO is the NASA Extreme Environment Mission Operations field test. Crewmembers can live in the

Aquarius re-space shown in the picture on the top right. We just completed NEEMO 21 over the summer with a 16-day mission with an international crew. There were six crewmembers over the period of 16 days and there were numerous participating organizations that you can see here. The objectives were to live in the habitat and conduct simulated EVAs outside to investigate the coral colonies in the surrounding area.

Moving to the next slide on [Slide 20], I show the science objectives that we are accomplishing during NEEMO. We incorporated authentic science with the help of the Coral Team from FIU, Florida International University. We built coral nurseries at 50 and 90 feet around Aquarius (respace) to understand how different types of corals grow at those different depths to evaluate how we might start to repopulate corals around the world. We also conducted follow-up science from the NEEMO 20 Mission from 2015. And we explored and collected new coral samples for the coral scientists to study.

Moving to the next slide on [Slide 21], we tested multiple operational concept at NEEMO. As with RATS we tested the integrated EVA science operations and looked at multiple operational concepts over varying time delays. For the bulk of the mission we had a 15-minute one-way communication time which means that we in mission control center message to the crew the soonest you would hear back from them would be 30 minutes later. So we were interacting with an integrated science team of coral experts. We also tested navigation, map and traverse planning technologies and operational concepts as well as joint robotic EVA operation. To do this I'll move to the next slide, [Slide 22] and talk about NEEMO technology that we tested this last year.

We had digital cue cards using an underwater iPad to show procedures and traverse plans for the crew real-time on EVA. We use an IV or Intra-Vehicular activity support system. So while two crewmembers would be out on EVA

one crew member would be supporting them from inside the habitat and be able to help them through the EVA as mission control was a 30-minute round trip delay away. We also tested new science sampling tools in a geology sampling kit that you can see pictured here.

Moving to the next slide [Slide 23], I'm going to move on from analog integrated testing and talk to you about once there are actually boots on the ground on another planetary surface what are the instruments that we actually want to put in astronaut's hands to enable them to have a higher resolution look at the rocks that they're investigating. So moving to the next slide [Slide 24], I want to briefly go over what we mean when we say field portal instrument. So the goal of any instrument here is to maximize science which will really enable astronauts to be the best as possible science scientific data real-time on another planetary surface while increasing or at least not detracting from the efficiency of a real-time EVA scenario. EVAs are strictly planned and they're limited in time because of the consumables and, you know, oxygen and food and everything that astronauts need to operate another planetary surface. So we want these instruments to not put a wrench in the works but to actually increase the efficiency of understanding the scientific context of an area of interest.

So these instruments influence sample collection in that they can help an astronaut if they have say ten samples they've collected but they only have room for five to bring back. These instruments can help (high-grade) those samples to figure out which five they want to return to Earth. And they could also influence situ data analysis that might inform what an astronaut does next on their traverse.

Moving to the next slide on [Slide 25], I want to briefly talk about the 30 team that I'm a part of as Laura Bleacher will be talking to you after me. We're part

of the live survey team or the Remote in Situ and Synchrotron Studies for Science and Exploration Team. PI'd out of Stony Brook University but we have participation from a number of institutions around the country and we're funded through the Solar System Exploration Research Virtual Institute which conducts - combines science and human exploration objectives.

So I want to talk to you about our objective of specifically the field team so I'll move to the next slide on [Slide 26]. So the fieldwork incorporated with the RIS⁴E project we first start with a science question. We want to answer a new and exciting and compelling science question. Then we identify a fleet of field portable instruments that make sense to address this science question. We want to evaluate the role that these instruments might play in an situ analysis to answer these questions. And then finally we want to provide recommendations to the human exploration community for how you might incorporate these instruments into an operational concept as well as think about what technology needs to be developed for future missions to Mars, the moon or small bodies.

The next slide [Slide 27] actually shows our field structure. And Laura's going to stay on after I get off and I'm sure she'd be willing to take questions about this as she is heavily involved with planning and execution of the field campaign. So here is sort of what our field teams look like in the field. We have a simulated astronaut crew. In this case we had a crew of three with two field geologists and one astronaut from the Johnson Space Center. We had a number of instrument teams that I'll talk about here in a minute but each instrument team consisted of two scientists to operate the instrument and feed the data taken from these instruments into the ongoing EVA that the crew was completing.

And we also had something that was really unique and exciting in that we brought science journalism students out in the field with us. So Laura was heavily involved in this project. We brought students from Stony Brook University out in the field with us and they were able to embed in our active field research team real-time. They were out with us the entire campaign and they learned what it was like to actually be embedded in a scientific field campaign. And we were actually able to travel up to Stony Brook ahead of time. They were able to come down to the Goddard Space Flight Center to understand how science journalism works from inside NASA.

Moving to the next slide on [Slide 28], I show the field site that we operate in on the Big Island of Hawaii. We worked in the Southwest (Risk) Zone of the Kilauea volcano. It you can actually see in the bottom right corner a picture of the lava flow that we work on. In the top right of that picture you can actually see the Kilauea Caldera, that large circle at the top of the image. The dark flow that the yellow arrows are pointing to is actually the flow that we work on. And it had erupted from those fissures that are outlined in the - by the redlines on the picture.

So what RIS⁴E is doing is using these instruments to study the physical volcanology and how the flow is in place as well as the chemistry and the mineralogy of both the flow itself and any alteration products that form on the top of flow. Moving to the next slide on [Slide 29], I introduced why the flow was selected. We picked the December 1974 flow as an analog due to its desert - the fact that it's a desert environment with brief damp periods so it looks like what we think the surface of for example Mars might look like. There is alteration on the surface of the flow that results from the active Kilauea plume coming from the Caldera on the last slide that interacts with the lava flow itself.

If you look in the back of this image you can actually see sort of a reddish brown plume coming up from the horizon. That's the plume coming up from the active Kilauea Caldera. It comes down slope toward us in the picture and when it rains this gaseous plume actually interacts with the surface of the flow and creates these interesting alteration products that we're using the field portable instruments to study.

The '74 flow also has the Basaltic flows that are interspersed with the basaltic ash and eroded the basaltic sediment like similar to what we see on another planetary services. And also similar is the low-slope morphology that we see elsewhere. So all these regions combine into why we've selected this plume as an analog study-site.

Moving to the next slide on [Slide 30] I show pictures of all the field instruments that we tested as part of the RIS⁴E field campaign. We have broad field of view instruments that are sort of stand offs. And the theory is here that in the Desert RATS concept that I mentioned earlier you as an astronaut would roll up in your rover and initiate these instrument measurements before you got out of your rover to conduct your EVA. So we had a multispectral imager as well as a LiDAR which gives surface texture information about the outcrop. We select these images ahead of time as an overlay for all the other data that you collect while you're on the EVA.

We also had ground penetrating radar which probes the subsurface and we had instruments for in situ chemistry and mineralogy like an x-ray fluorescent spectrometer which you could see in the lower left and the x-ray diffraction instrument which you can see in the bottom middle picture that give chemistry and mineralogy. Finally, we had a (kite) to provide airborne data for site context. UADs are not allowed in the Big Island of Hawaii as well as in all national parks so we actually use a kite to provide the aerial imagery to give

the astronaut some context over the area they're exploring. The next slide is [Slide 31], so some of the data that we've collect with these instruments. The types of things that we're investigating at the '74 flow are the alteration-codings that I mentioned form as a result of this volcanic plume and the flow itself, and we use those in situ chemistry and mineralogy instruments as well as the multispectral image to investigate what these coatings look like. Do the very long the length of the flow? What are they made out of? How do they form and might we see them on other planetary surfaces? You can actually see some data here on the last - the picture on the left from the handheld x-ray fluorescent instrument.

We also have the Solfatara site at '74 which is very similar to sites the rovers have seen on the Martian surface. Solfatara sites result from when there's latent heat sticking around, there's still heat coming up on the Big Island of Hawaii that then interacts with the younger flows that are sitting on the surface and create these really high sulfur alteration products on the surface. And you can see some multispectral imaging work from the lab in the middle picture here. And we also investigate flow morphology and how to flow it in place. The picture on the right is I think a really neat image and it's a picture from the (kite) that I mentioned.

In the middle sort of on the top half of the picture you can see a lighter toned sort of circle sticking out and it's surrounded by the dark block of the '74 flow. That little circle actually represents the older flow that the '74 floor came in on top of. You can use images like the (kite) to figure out how this new flow was in place, how it interacted with the terrain underneath it and this picture really shows that.

So the next slide [Slide 32], we want to answer these science questions yes but we also want to think about the operational considerations of using these

instruments. So while we've shown that we actually really do have increased science value from using these instruments in the field we want to think operationally about what affect incorporating these instruments has on the overall EVA timeline. So what RIS⁴E doing is building off of the old desert RATS heritage to look at these operational timelines and I'll show you an example of that.

You move to the next slide on [Slide 33], this shows the geological map of the Desert RATS 2010 test area. And each one of those colors represents a different unit that the science team picked out ahead of time before the rover had gotten to the field sites just using Google Earth images. And what the black diamonds represents is a sample that was picked up by one crew during Desert RATS 2010. So there are ten diamonds there that each represent a different sample. In the field it was really hard to tell these samples apart. If you had an unlimited time as a field geologist in this area you would be able to pick one out from the other and that's because you do have unlimited time and resources relative to what you have in a planetary exploration environment.

However, on RATS we were having EVAs that were sometimes as short as 25 minutes which is just really not enough time to really dwell on a sample and think hey how does the sample correlate to the one I saw the day before or even several days before? What field portable instruments give you is the ability to interrogate at a higher resolution the geochemistry of an area and record these data so you can compare one day to the next. And as a field geologist it's really valuable in these limited time, limited consumable constraints to be able to tie scientific observations together with ones you made days before.

So you can see the darker flow that's sort of on the bottom left-hand corner of this picture, that's the FP crater flow. That's very visually distinct. It's a lot younger than the flows in volcanoes around it. It's really basically distinctive in the field. There were three samples collected from FP as indicated by the three diamonds around that (cone) in the flow that were very easy to tell apart in the field real-time. However, the other seven samples it was really challenging with the amount of time we had left to tell them apart.

So if you move to the next slide on [Slide 34] this shows hand-held x-ray fluorescent data which gives chemistry that isolates these ten samples into different groups. And you can clearly see that three distinct units are pulled out from this (hand-held) x-ray fluorescent data. And if you move to the next slide on [Slide 35] you actually show when you put these back on the map the blue circles correspond to those three examples that I mentioned came from the FP crater flow. So you can clearly see that there is that, the two samples taken that are indicated by the red circles actually indicate that there is a different volcanic flow flowing off to the west of FP crater.

And just because of the limited time we had we as the crew were not able to pick up this flow in real-time. But having these hand-held x-ray fluorescent data enabled us to identify that there are more flows in this area. And had we known that real-time during Desert RATS we might have attempted to do more EVAs off to the west of FP to collect more examples from the different units before returning to Earth.

Operationally, however, every time you take a hand-held x-ray fluorescent measurement it costs you two minutes of time. So that's one minute that's the actual integration time of the instrument. It's the time that you need to hold the instrument against the rock itself. But you also need an additional minute to document the data, take picture of the rocks that you sampled, note it in your

field notebook or in the case of Desert RATS because we couldn't have a notebook we actually talked out loud and recorded it about the sample description and the site context.

So every time you get one of those numbers with the hXRF it costs you two minutes of time. And that doesn't sound like a lot but the Apollo EVAs are only eight hours long they had a lot of ground to cover. So you want to think about as a crew member the cost versus the science value added of each one of these instruments and these are the types of lessons learned that we're trying to pull with the RIS⁴E field test.

So if you move to the next slide on [Slide 36] just want to talk about some final thoughts about field portable instruments before I move on. So through the RIS⁴E project we've identified that these field portable instruments are highly beneficial. They both help you to high grade your samples and figure out which samples you want to bring back for return to Earth as well as getting real-time contextual insight. In the case of RATS that was identifying a flow there we weren't necessarily able to pick out without the instrument. However, selecting an instrument suite is nontrivial and should be a priority a mission planning regardless of which destination we end up visiting. And through RIS⁴E work is ongoing to investigate how these field portable instruments might fit into a future EVA operational concept. So we have to continue testing them in relevant field environments to continue to pull all these lessons learned and figure out what technology we need to work on now.

Moving to the next slide on [Slide 37], the last thing I want to talk about is now that we talked about sort of integrated testing of those with all of the technology and operational context you'd need for planetary surface exploration then move down and so once you're on an EVA what instruments do you need to conduct science on another planet? We want to talk about the

people who are going to be using those instruments, the astronaut crew who are going to take the scientific instruments we're working on and actually deploy them in the field and that sees forward into a successful exploration mission.

So if you flip to the next slide [Slide 38], I show some context of the science training history of the Apollo astronaut. We like to say that for every Apollo astronaut that flew to the surface of the moon they had the equivalent of a Master's degree in geology. They had hundreds of hours of classroom training and of field training. So in the top left picture you can actually see one of the geo trainers training the astronaut and training them in the geologic map of the sites they're going to visit during Apollo as well as working them into the traverse plan so they feel comfortable with what they'd be executing on the lunar surface.

In the lower left you see one of the field trips that the Apollo astronauts went on with field geologists to teach them about interpreting rocks real-time. The picture on the right shows the document that was produced and you can look up if you're interested that documents everything I've just said, how the Apollo astronauts were trained and why and which field sites they went to. Moving to the next slide on [Slide 39], we have a current look at the astronaut training. So for every astronaut that's selected they go through a two-year candidacy phase or their designated astronaut candidate and they get trained in a whole host of things including International Space Station operation, how to do an EVA on ISS. They learn how to stay alive in space for long periods of time. They get health training. They get human factors training all over a period of two years.

They also get geology and science training and that includes just like Apollo they get classroom training like you can see in the lower left where they learn

about the fundamentals of geology, of Earth science and of planetary science. And then like and you can see in the upper left you take them in the field. Again it's trained field geologists with these astronauts to teach them how geologists and scientists do work in the field.

In the upper right you see another phase of astronaut training. Once the astronaut candidates have graduated and they're full astronauts that are able to be assigned to a flight we run them through - we give them the option to be run through field -assisted training. So every time that there's a field geologist connected with the program who has a field campaign they can actually take an astronaut with them in the field to embed them in our field campaign similar to the science journalist from RIS⁴E. This picture is a picture of Don Pettit out just three weeks ago as I mentioned in the Desert RATS 2010 traverse follow-up project. He's deploying seismometers in the FP crater area.

And finally in the lower right astronauts actually take part in these analog missions that I mentioned earlier. This picture is Kjell Lindgren in the Desert RATS 2011 field test and Kjell since then has flown a six-month mission at the International Space Station. We also recently just this summer had a couple astronauts as part of the NEEMO crew. And it's a great way for these astronauts to learn how to do science in a real operational environment.

So next slide [Slide 40], I show a picture that sort of is the result of this crew training. So this is an actively erupted volcano in Russia and a crew member in ISS actually took this picture. And they flew over this erupting volcano on one orbit of ISS and said, you know, hey that looks like a volcano that I'm not sure, you know, really anybody else knows is erupting. And the next time ISS came around he had a camera ready and snapped this picture. And pictures like this really enable volcanologists who study active eruptions like this to

better understand and get a better look at how these are options happen and what the dynamics of them are.

And it's because these astronauts understand what the process is, what's important about it and they can document and observe and let the crew on the ground know that these eruptions are going on. So moving to the next slide [Slide 41], I think I'm preaching to the choir here but there's a lot of value in terms of exploration. And these are all pictures from of course the Apollo 11 lunar landing, the first boot print made in the lunar soil. And we also have a crowd of over 10,000 people watching this landing in Central Park in New York. So a lot of people watched this landing even back in the 60s and I think people are just as excited about it today.

So I'll show you the next slide [Slide 42], almost done. We have sort of this is, you know, today's NASA. And that is the NASA that's explored - exploring low Earth orbit and hoping to eventually go on a journey to Mars. So I actually I took the picture on the upper right and this is from a launch just on October 17 of a Cygnus launch so one of these private companies that's launching these supplies to the International Space Station. There's a NASA picture on the left of the launch and on the right that bright dot you see in the middle of the image is a picture of the launch from my apartment in Washington DC.

In the rooftop on my apartment building is packed with people watching NASA TV and watching the launch. So people are still really excited about it. And Elon Musk in charge of SpaceX, I'm sure you guys all know he's planning on sending the driving capsules to the Martian surface here, and I think it's really captivating a lot of the American public.

So finally on the last slide [Slide 43], I just want to say thank you guys for having me. And if anybody has any questions that's looking into this reported later, please feel free to email me and my email address is on the slide. And thanks for having me and I'll take questions.

Jeffrey Nee: Thanks Kelsey. That was a great talk and I know we had to go really fast and I don't want to hold you so just cut us off whenever...

Dr. Kelsey Young: Oh know, I still have a few minutes...

Jeffrey Nee: Okay but while people are unmuting their phones I just had a couple questions of my own just to start off. And just from your experience with all the analogs I'm most curious in what do you think are the biggest takeaways from each of the challenges like for example when you guys were simulating the communications delay or you were testing all of the equipment what are some of the biggest takeaways that you - and insights that you gathered from doing all these analog tests?

Dr. Kelsey Young: Yes thanks, great question. So one thing that actually is pretty recent and fresh in my mind is that for NEEMO 21 just this past summer; I was helping out as best I could, and one of the roles that I have was the science communicator. So when the crews were on EVA, you know, underwater with looking at these corals I was interfacing between the corals scientists sitting next to me and the crew on EVA; really doing the science.

And so with this 30-minute time delay the coral scientists would say, "Oh wow, there's a coral that I could see in their helmet camera that they just past; that we'd really like to sample." But by the time my communication would get to them they would be long gone from that site, right? So this communication delay, you think about directing the communication structures and the

technologies but actually from a science perspective and from conducting science and getting really valuable data and samples out of it having a really highly trained crew is crucial. And so what the crew kept saying was, “You know, we want more before we launch one of these missions, and want to understand how to think like you guys. We want to understand exactly what we’re looking for so we can be your ambassadors.”

And I think these communication delays really stress that point. It’s crucial to have a crew that can say this coral is what these scientists are looking for or this rock is exactly what those geologists would want. And so crew training came up a lot and, you know, we had a lot of fun and I know the crew had a lot of fun learning all about coral. I certainly learned a lot about it. So that was sort of one thing that came up again and again and I think the whole team felt the same way.

Jeffrey Nee: Great I know because you said you - they pretty much got a Masters level of education in - did they actually get a Masters? I mean I’m just curious.

Dr. Kelsey Young: I don’t think so.

Jeffrey Nee: Okay.

Dr. Kelsey Young: Eleven of the twelve people that flew were pilots so they didn’t come from a scientific background. On Apollo 17, Jack Schmitt was a geologist and had a PhD in geology so he's the exception. But they knew quite a lot about both specifically their field site. Their field trips were tailored toward the specific site they were visiting so they really understood the features that they were going to see and they had a lot of classroom training to back it up.

Jeffrey Nee: So I guess NASA doesn't have like an accreditation to give out degrees or anything no?

Dr. Kelsey Young: I should really look into that.

Jeffrey Nee: And I love all the pictures that your - and people should interrupt me if I'm blabbing too much if they have questions but I love all the pictures. Is there a specific gallery or I should just go to the Web site or actually... Web sites if they want all the pictures?

Dr. Kelsey Young: Yes, there is. Actually NASA has sort of a centrally located site for analogs and you can search it if you just Google NASA analogs. And it actually has all of these analogs that I talked about. It's got RATS. It's got NEEMO. I looked through the NEEMO pictures just to make this talk and there's - I was really having trouble picking them. So there's a lot of really great photos. RIS⁴E also has a Web site. And if you Google RIS4E R-I-S-4-E you can actually go to the Web site of the team that Laura and I are both a part of to get pictures from us.

Jeffrey Nee: Okay.

Dr. Kelsey Young: And one other thing that I think Laura can elaborate on too is that the science journalists produced a really amazing Web site that's reporting RIS4E.com so reporting R-I-S-4-E that has sort of the reports and articles that they've produced both from interviewing us scientists before we left in the field and after we got back. So that has a lot of field photos and some interesting science journalism student articles.

Jeffrey Nee: Great. And then I decided a question for you since your background is in geology and if you could go to, you know, say the moon or Mars or an

asteroid I mean which one do you think is the most geologically rich in terms of science?

Dr. Kelsey Young: Well I love them all. If they're going to send me somewhere I'll happily hop on the rocket regardless of where it's going. I think there are a lot of really compelling science questions about - at all three of them. I think, you know, Apollo and studying the samples since Apollo has raised some really rich lunar questions that I would love to go back to the moon to sample.

For my PhD I studied impact craters and there's one of the biggest on the far side of the moon that I'd love to visit. I think there's a lot of questions about small bodies, asteroids about the early solar system formations. And of course Mars is sort of it's a known and an unknown right? We know a whole lot about it but everything we learn more about it raises different and more compelling science questions. So I really I can't pick a favorite.

Jeffrey Nee: Okay, because what are the NASA plans for going back to the moon? I always get different answers from different people and I don't know if you've heard anything?

Dr. Kelsey Young: Yes I think it's constantly evolving but we currently have the R Mission on the books to go back to -- the Asteroid Redirect Mission, and that's to send a robotic mission to an asteroid, get a sample, bring it closer to the moon and then send human beings to that sample in orbit around the moon to conduct science - small body science. So the R Mission is still on the books and that of course involves lunar orbit. So that's sort of where the plans are right now but they're constantly evolving and of course today's Election Day so we'll have to see.

Jeffrey Nee: Right, that's right.

Dr. Kelsey Young: But I should probably sign off and leave you with Laura. And Laura's been intimately involved with many of the things I talked about today so I'm sure she is more than capable to answer any remaining questions.

Jeffrey Nee: Sure. And we appreciate that you put your contact info at the end of the slide so...

Dr. Kelsey Young: Yes.

Jeffrey Nee: ...thank you for that.

Dr. Kelsey Young: Definitely please, please email me yes.

Jeffrey Nee: Okay thanks Kelsey.

Dr. Kelsey Young: Thank you and thanks Laura.

Laura Bleacher: Yes, no problem.

Jeffrey Nee: Laura I'm not sure if you had anything in particular to add to Kelsey's talk or anything before we just jump in the questions because I have a whole list honestly.

Laura Bleacher: Okay Yes, so Kelsey did mention the Web site that was put together by the journalism students that we worked with on the last RIS⁴E build campaign. I don't know if she actually mentioned the URL. That URL is reportingRIS4E.com. You know, with NASA we like acronyms so RIS again as she mentioned earlier is an acronym so it's reportingRIS4E.com.

And there you can find tons of information about the last field campaign that happened about a year and a half ago. And we are going to be doing another field campaign that's coming late spring early summer probably in early June. And this field campaign will actually take place in New Mexico and we'll be using a lot of the same science instruments that we used and having a lot of the same the same team members -- a few new ones -- that we had this last go-round but we'll be working with a whole new slew of journalism students.

And so they'll be putting out some additional products and kind of adding to the work that the previous students did kind of documenting the science and fieldwork that Kelsey and her team have been doing so definitely stay tuned for that. Another way to follow along with the work that NASA's doing in regards to preparing for human exploration of the solar system beyond low Earth orbit is of course the NASA Web site which I know can kind of be a bear to navigate. But if you go to nasa.gov/mars that's where you can find some links to a lot of the work that we're doing with what we call the journey to Mars which Kelsey showed early on in her presentation, a slide or two related to the - what we called the architecture of our journey to Mars in terms of the various components and, you know, and testing and things that need to happen. But then low Earth orbit and then extending outwards to the vicinity of the moon and then of course actually on to Mars and possibly also involving an asteroid.

So definitely, you know, stay tuned to the NASA Web site, follow along on - if you do [#journeymars](https://twitter.com/journeymars) that's NASA's hashtag that we're using to share with the public on social media the different steps that we're taking to prepare for human exploration. So those are some great ways to follow along.

- Jeffrey Nee: Thanks Laura. And I had more questions about the journalism project. If, you know, museums are or planetariums are paired with a university you're talking about journalism students is that right?
- Laura Bleacher: Yes, yes these are primarily undergrad students that we worked with and that we will be working with again this time and a couple of graduate students who have kind of worked with their professors to act as mentors for the undergrads.
- Jeffrey Nee: And is that a closed application process if people are interested or...
- Laura Bleacher: So we're actually we have a specific partner with this program and it's the Stony Brook School of Journalism. And the reason for that is that the principal investigators, or the person who leads the overall RIS⁴E Team is Dr. Tim Glotch who is a professor at Stony Brook University. And so Stony Brook University has a - is a very good journalism program. And they also have an organization called the Alan Alda Center for communicating science. So as a whole they're very dedicated to science communication both science writing as well as science journalism as well as helping train scientists and engineers and managers to be effective public speakers in terms of sharing the - either the science work that they do or the work of their organization. So we're specifically partnered with them, you know, but we're definitely open to talking with others who might be interested in learning more about this program and how they might replicate it within their organizations.
- Jeffrey Nee: Great. All right let's see any other questions for the speakers or for Laura? Well okay I'm happy to close out early. Laura thank you so much for coming and filling this time and getting us healthy and for all the great work that you do.

Laura Bleacher: No problem. It's my pleasure. And I just want to, you know, thank you and also thank all of the listeners today for the great work that you do in sharing science with the public. We really appreciate it. And it's hard for us to be in lots of different locations around the country and elsewhere and so we really appreciate the work that you guys do. So thanks again and, you know, please feel free to contact me as well if there are additional questions that I can answer or additional, you know, resources that I can point anyone to. I'd be happy to do that.

Jeffrey Nee: Great. So thank you to everyone for joining us today. This was a great way to get into this whole analog, mass analog thing. And I'm really interested in seeing where this goes. So just remember to everyone that this talk will be reported and archived on the Alliance site and on the Solar System Ambassador sites if anyone wants to hear it again or if you want to your education staff to listen to it too.

As Laura said you can email us or email Kelsey with any questions you might have. Again my email address is jnee@jpl.nasa.gov. And remember on Thursday we have an Earth Science telecon about Mapping Rogue Methane Sources. As always the most up to date information is on our Web sites. Thank you again everybody and have a wonderful day. Don't forget to vote. Bye Laura.

Laura Bleacher: Thanks. Goodbye.

Jeffrey Nee: Bye everybody.

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